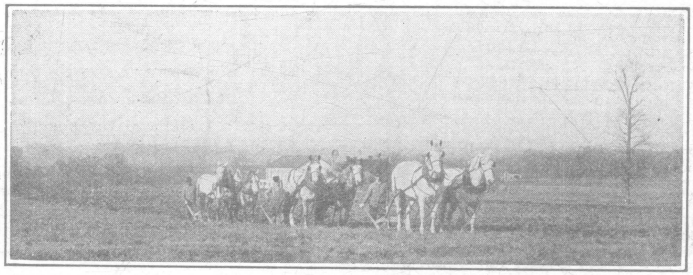
FEEDING WORK HORSES.

A COMPARISON OF CORN AND OATS.

OHIO
Agricultural Experiment Station.

WOOSTER, OHIO, U. S. A., JUNE, 1908.

BULLETIN 195.



The Bulletins of this Station are sent free to all residents of the State who request them. Persons who desire their addresses changed should give both old and new address. All correspondence should be addressed to

EXPERIMENT STATION, Wooster, Ohio.

OHIO AGRICULTURAL EXPERIMENT STATION

GOVERNING BOARD

THE AGRICULTURAL COMMISSION OF OHIO

Columbus

A. P. SANDLES, *President* — C. G. WILLIAMS — B. F. GAYMAN, *Secretary*
S. E. STRODE — H. C. PRICE

STATION STAFF

CHARLES E. THORNE, M. S. A., *Director*

DEPARTMENTAL ORGANIZATION

ADMINISTRATION

THE DIRECTOR, *Chief*
WILLIAM H. KRAMER, *Bursar*
D. W. GALEHOUSE, *Assistant*
DORA ELLIS, *Mailing Clerk*
GLENN HALL, *Engineer*
W. K. GREENBANK, *Librarian*
W. J. HOLMES, *Printer*

AGRONOMY

C. G. WILLIAMS, *Chief*[1]
F. A. WELTON, B. S., *Associate*
WILLIAM HOLMES, *Farm Manager*
C. A. PATTON, *Assistant*
C. A. GEARHART, B. S., *Assistant*
E. C. MORR, *Office Assistant*
C. H. LEBOLD, *Asst. Foreman*

ANIMAL HUSBANDRY

B. E. CARMICHAEL, M. S., *Chief*
J. W. HAMMOND, M. S., *Associate*
GEO. R. EASTWOOD, B. S., *Assistant*
DON C. MOTE, M. S., *Assistant*
W. J. BUSS, *Assistant*
ANTHONY RUSS, *Herdsman*
E. C. SCHWAN, *Shepherd* (Carpenter)

BOTANY

A. D. SELBY, B. S., *Chief*
TRUE HOUSER, B. S., *Assistant* (Germantown)
F. K. MATHIS, *Office Assistant*
D. C. BABCOCK, A. B., *Assistant*
RICHARD WALTON, B. S., *Assistant*
ALFRED S. ORCUTT, M. S., *Assistant*

CHEMISTRY

J. W. AMES, M. S., *Chief*
GEO. E. BOLTZ, B. S., *Assistant*
J. A. STENIUS, B. S., *Assistant*
C. J. SCHOLLENBERGER, *Assistant*
MISS MABEL CORBOULD, *Assistant*

CLIMATOLOGY

J. WARREN SMITH, *Chief* (Columbus)[2]
C. A. PATTON, *Observer*

COOPERATION

THE DIRECTOR, *Chief*
W. L. ELSER, B. S., *Executive Assistant*[3]
H. P. MILLER, B. S., *County Agent* (Ravenna)
F. L. ALLEN, A. B., *County Agent* (Burton)
W. M. COOK, A. B., *County Agent* (Xenia)
M. O. BUGBY, B. S. *County Agent* (Warren)
A. L. HIGGINS, B. S., *County Agent* (Dayton)
F. N. MEEKER, *County Agent* (Hamilton)
M. C. THOMAS, *County Agent* (Troy)
C. ELLIS BUNDY, *County Agent* (Paulding)

DAIRYING

C. C. HAYDEN, M. S., *Chief*
A. E. PERKINS, M. S., *Assistant*
T. R. MIDDAUGH, *Office Assistant*

ENTOMOLOGY

H. A. GOSSARD, M. S., *Chief*
J. S. HOUSER, M. S. A., *Associate*
W. H. GOODWIN, M. S., *Assistant*
R. D. WHITMARSH, M. S. *Assistant*
J. L. KING, *Assistant*

FORESTRY

EDMUND SECREST, B. S., *Chief*
J. J. CRUMLEY, Ph. D., *Assistant*
A. E. TAYLOR, B. S., *Assistant*
J. W. CALLAND, B. S., *Assistant*
D. E. SNYDER, *Office Assistant*

HORTICULTURE

W. J. GREEN, *Vice Director, Chief*
F. H. BALLOU, *Assistant*, (Newark)
E. J. RIGGS, B. S., *Assistant*, (Columbus)
PAUL THAYER, M. S., *Assistant*
C. W. ELLENWOOD, *Office Assistant*
ORA FLACK, *Foreman of Orchards*
W. E. BONTRAGER, *Foreman of Grounds*
C. G. LAPER, *Foreman of Greenhouses*

NUTRITION

E. B. FORBES, Ph. D., *Chief*
S. N. RHUE, B. S., *Assistant*
F. M. BEEGLE, B. S., *Assistant*
L. E. MORGAN, M. S., *Assistant*
CHARLES M. FRITZ, M. S., *Assistant*

SOILS

THE DIRECTOR, *Chief*
C. G. WILLIAMS, *Associate in soil fertility investigations*
J. W. AMES, M. S., *Associate in chemistry*
GEORGE N. COFFEY, Ph. D., *Associate in charge of soil survey*
E. R. ALLEN, Ph. D., *Associate in soil biology*
H. FOLEY TUTTLE, M. S., *Assistant*
A. BONAZZI, B. Agr., *Assistant*
JOHN WOODWARD, M. S., *Assistant*

DIVISION OF EXPERIMENT FARMS

C. W. MONTGOMERY, *General Superintendent*

District Experiment Farms

Northeastern Test-Farm, Strongsville.
EDWARD MOHN, *Resident Manager*

Southwestern Test-Farm, Germantown.
HENRY M. WACHTER, *Resident Manager*

Southeastern Test-Farm, Carpenter.
H. D. LEWIS, *Resident Manager*
LEWIS SCHULTZ, *Horticultural Foreman*

Northwestern Test-Farm, Findlay.
JOHN A. SUTTON, *Resident Manager*

County Experiment Farms

Miami County Experiment Farm, Troy
M. C. THOMAS, *Agent in Charge*

Paulding County Experiment Farm, Paulding
C. ELLIS BUNDY, *Agent in Charge*
HARRY RAY, *Foreman*

Clermont County Experiment Farm, Owensville
VICTOR HERRON, *Agent in Charge*
HOWARD ELLIOTT, *Foreman*

Hamilton County Experiment Farm, Mt. Healthy
VICTOR HERRON, *Agent in Charge*

[1]With leave of absence. [2]In cooperation with Weather Service, U. S. Department of Agriculture.
[3]In cooperation with Bureau of Plant Industry, U. S. Department of Agriculture.

BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 195. JUNE, 1908.

FEEDING WORK HORSES.

A COMPARISON OF CORN AND OATS.

BY B. E. CARMICHAEL.

Problems connected with the feeding ot work horses are doubtless of as wide interest as any problems in live stock management Practically all farmers, whatever particular branch of farming they may be engaged in, have occasion to feed work horses. Besides farmers, commercial firms of various classes keep horses in large numbers for work purposes and they, too, have a deep interest in methods of feeding that will lessen the cost of maintaining work horses, without decreasing their efficiency.

Whether feeds are high or low in price, it is well worth while for feeders to exercise great care in the selection of rations, so as to use the ones that are most efficient and economical. With the present exceedingly high market prices for all kinds of grain feeds, it is especially important that a judicious selection of feeds be made, for much waste may result if attention is not given to this phase of stable management.

Of all grain feeds used in this country none is in higher repute with horsemen than oats. Many horsemen believe oats to be the best single grain feed for horses, whether kept for draft or for road purposes. It has been stated time and again by practical horsemen and others, that horses fed upon oats display more life, keep in better condition and endure work, especially during hot weather, better than do horses which receive a grain ration made up largely or exclusively of corn. And this belief in the efficiency of oats as a grain feed for horses is so strong with some horsemen that they are willing to pay exorbitant prices for oats, rather than feed corn.

A study of the chemical composition of corn and of oats fails to show any good reason for the exceedingly high favor in which oats are held, or for corn being considered so totally unfit for the use of horses, especially when at hard work. It has been claimed that oats contain a stimulating principle known as "avenine" which gives great spirit to horses. The existence of this stimulating principle has not been proved, and it is safe to say that its existence is very improbable. Even if it does exist, there is no evidence to indicate that it would have any special bearing upon the practical feeding of work horses.

On account of the wide-spread prejudice against corn and in favor of oats, an experiment, from which it is hoped that definite data may be secured in regard to this important subject, has been undertaken at this Station. The plan of this work calls for a long-time experiment—not one of a few days' or weeks' duration, but one that will continue for a number of years.

The work was begun in the spring of 1907, and the results of the experiment up to the present time are so striking that it has been thought best to give them to the public at once, with the understanding that further work is being done along this line and that there is a possibility of different results being secured later.

PLAN OF EXPERIMENT.

The horses used in the first forty-eight weeks of this experiment were six mature grade Percheron geldings, belonging to the Department of Agronomy of this Station and used for general farm and team work. The horses and the work, then, are fairly comparable with horses and work commonly found upon farms in Ohio and adjoining states. In age, the horses ranged at the beginning of the experiment, from seven to eighteen years old. The two horses of each team are of approximately the same age, however. While there are some differences in the conformation, size and disposition of the various horses they are a fairly uniform lot. In order to secure an accurate comparison of oats and corn one horse in each of the three teams is fed oats, while the other receives corn. With the exception of a very few days the two horses which comprised a team were, for 48 weeks, worked together; that is, it was very unusual for one horse of a team to work while the other horse was idle; this assures an equal amount of labor being performed by each horse in a given team and, therefore, permits a direct comparison of the two feeds.

The horse called Tom is by nature a very "easy keeper," and the cost of his maintenance is relatively low on this account. This fact should be borne in mind in making use of Tables III and IV. At present the horses which received corn during the time covered

by this bulletin are fed oats, and corn is fed to the horses which formerly received oats. In this way, it is hoped that individual differences in the horses may be overcome to some extent.

Until April 19, 1907, all six of the horses were fed practically alike on a grain ration made up chiefly of corn and oats. A small amount, one-half pound, of linseed oil meal was fed for awhile prior to April 19th. On April 19th the change from a mixed grain ration to the separate grain rations was begun, and on April 25th the single grain rations of corn and oats respectively were in use. The initial three-days' weights (See Table II) were taken May 16th, 17th and 18, so that the experiment began after the horses had been on the single grain rations for three weeks.

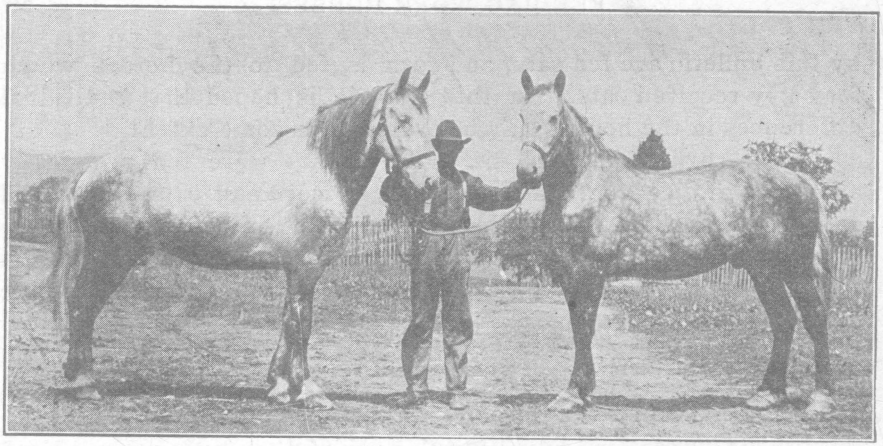
The interruptions in the regular use of the single grain rations were very few. One horse, Bill, was sick for a few days at two different times, and some bran and oats were fed. There was no evidence to indicate that corn was responsible for this slight indisposition, the purpose of using other feeds being to induce the horse to eat. The continued use of corn alone afterwards caused no recurrence of the indisposition, and corn can in no sense be held responsible for the trouble. It has been assumed, therefore, for convenience in making the calculations, that this horse was fed the usual grain ration during these two very short periods, covering in the aggregate about ten days. Frank, Bill's team-mate, was "off feed" for a short time in February, but, again, the exclusive use of oats cannot be considered the cause.

The effect of the two rations upon the health of the animals, upon their ability to stand hard work, especially in hot weather, and upon the live weight is being observed.

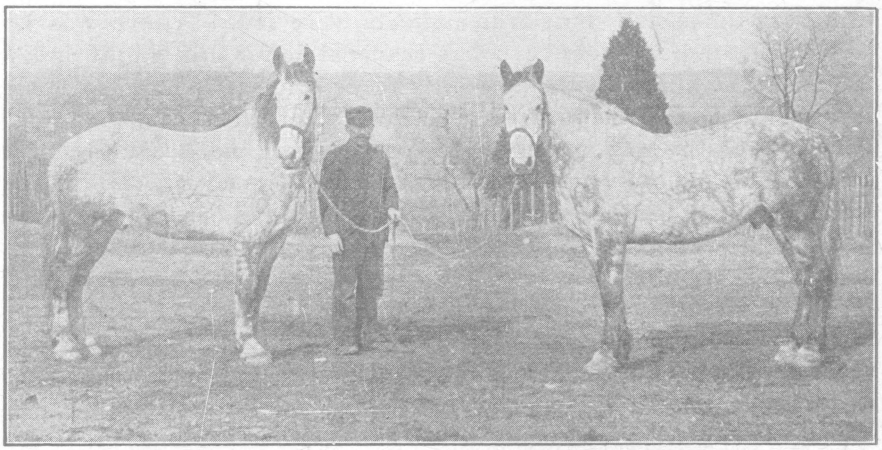
FEEDS USED.

The oats used were grown on the Station farm and, on account of the unfavorable season in which they were grown and harvested, were not of the very best quality. Samples that were tested weighed from 28½ to 31½ pounds per bushel. The corn was, for the chief part, grown on the Station farm, but some was shipped in from the western part of the state. The crop of 1907, grown on the Station farm, and the corn shipped in were not quite as good as the corn from the crop of 1906, fed until November 1st. From November 1st to January 24th the shelled corn that was shipped in was fed, after which the crop of 1907 was used.

The hay used is chiefly a mixture of clover and timothy, with some slight mixture of other plants.



Frank; fed oats. August 5, 1907. Bill; fed corn.
After having received separate grain rations for 101 days.



Frank; fed oats January 3, 1908. Bill; fed corn.
After having received separate grain rations for 252 days.

Frank; fed oats. May 11, 1908. Bill; fed corn.
After having received separate grain rations for 380 days.

Table I gives the composition of oats, shelled corn and hay. The analyses presented in this table were made under the direction of Mr. J. W. Ames, Chemist of this Station.

TABLE I: Percentage composition of feeds.

	Moisture	Ash	Protein	Crude fiber	Nitrogen-free extract	Fat
Corn	11.673	1.390	9.630	1.830	71.220	4.257
Oats	10.235	3.410	12.500	10.901	59.424	3.530
Hay (Mixed, clover and timothy)	13.198	5.101	6.260	34.553	38 820	2.068

The plan is to feed as many pounds of ear-corn to one horse in each team as is fed of oats to the other horse. When shelled corn was fed, the amount was adjusted so as to equal the amount of ear-corn indicated above. In other words, for each pound of oats fed to the three horses which received this grain ration, a pound of ear-corn or its equivalent in shelled corn (the ear-corn of the crop of 1906 yielded, in August, 1907, 82.5 percent shelled corn) was fed to the other three horses. At first thought this would seem to be too small an amount of corn to feed, but, as will be shown later, the results of the experiment indicate that the horses were equally well fed. Approximately the same amount of hay was fed to each of the horses with the exception of one (Tom) which would not eat as much as the others. Any hay that was refused was weighed and its weight deducted from the total amount fed. See Table III for feed consumed by each horse.

WEIGHTS OF HORSES.

Weights of the horses were taken each week throughout the experiment. The weights were taken three days in succession at the beginning of the experiment, at the end of each four-week period, and at the close of the experiment. The purpose of the three-days' weights is to overcome the daily fluctuations in weight which may occur from various causes. These weights are presented in Table II. This table shows no very marked variations in weight. The variations that did occur cannot be said to be due to the feeds used, as some variations will occur even where the horses are fed alike.

TABLE II: Weights of Horses.

Date	Joe, fed corn	Jake, fed oats	Bill, fed corn	Frank, fed oats	Tom, fed corn	Dick, fed oats
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
May 16-17-18	1,555	1,453	1,493	1,470	1,527	1,349
" 24	1,570	1,446	1,468	1,430	1,510	1,330
" 31	1,570	1,452	1,500	1,450	1,520	1,340
June 7	1,544	1,460	1,492	1,422	1,512	1,336
" 13-14-15	1,573	1,443	1,484	1,427	1,543	1,358
" 20	1,570	1,436	1,494	1,458	1,540	1,370
" 28	1,542	1,422	1,494	1,450	1,540	1,354
July 5	1,550	1,420	1,474	1,450	1,550	1,370
" 11-12-13	1,535	1,423	1,484	1,480	1,540	1,369
" 19	1,480	1,420	1,474	1,474	1,542	1,370
" 26	1,522	1,410	1,460	1,460	1,550	1,390
Aug. 2	1,540	1,400	1,470	1,470	1,542	1,390
" 8-9-10	1,523	1,398	1,467	1,487	1,545	1,379
" 16	1,510	1,400	1,448	1,460	1,530	1,370
" 23	1,520	1,380	1,460	1,470	1,520	1,380
" 30	1,510	1,370	1,450	1,450	1,500	1,354
Sept. 5-6-7	1,503	1,363	1,451	1,451	1,497	1,355
" 13	1,510	1,364	1,470	1,456	1,520	1,360
" 20	1,524	1,400	1,470	1,430	1,540	1,380
" 27	1,518	1,380	1,450	1,450	1,520	1,360
Oct. 4-5-6	1,519	1,388	1,463	1,457	1,536	1,370
" 11	1,510	1,390	1,500	1,500	1,555	1,400
" 18	1,514	1,386	1,472	1,488	1,536	1,374
" 25	1,524	1,410	1,464	1,458	1,560	1,380
" 31, Nov. 1-2	1,534	1,413	1,489	1,495	1,568	1,413
Nov. 8	1,510	1,400	1,486	1,500	1,568	1,442
" 15	1,526	1,432	1,494	1,510	1,580	1,440
" 22	1,524	1,420	1,492	1,490	1,570	1,418
" 28 29-30	1,515	1,420	1 500	1,520	1,565	1,429
Dec. 6	1,520	1,430	1,510	1,526	1,546	1,400
" 13	1,544	1,466	1,532	1,542	1,590	1,468
" 20	1,576	1,480	1,500	1,520	1,586	1,460
" 26-27-28	1,580	1,475	1,513	1,573	1,598	1,473
Jan. 3	1,586	1,492	1,500	1,550	1,600	1,452
" 10	1 580	1,480	1,530	1,580	1,600	1,452
" 17	1,586	1,494	1,530	1,590	1,600	1,440
" 23-24-25	1,577	1,491	1,540	1,592	1,609	1,467
" 31	1,588	1,490	1,560	1,610	1,616	1,480
Feb. 8	1,610	1 522	1,526	1,600	1,630	1,504
" 14	1,626	1,512	1,540	1,582	1,640	1,510
" 20-21-22	1,622	1,483	1,551	1,603	1,609	1,452
" 28	1,620	1,500	1,546	1,580	1,610	1,500
Mar. 6	1,630	1,520	1,568	1,586	1,612	1,480
" 13	1,630	1,530	1,570	1,584	1,636	1,504
" 19-20-21	1,574	1,493	1,551	1,551	1,624	1,453
" 27	1,540	1,460	1,500	1,500	1,582	1,410
Apr. 3	1,550	1,460	1,504	1,490	1,580	1,410
" 10	1,560	1,454	1,506	1,460	1,570	1,406
" 16-17-18	1,535	1,438	1 486	1,473	1,545	1,389

Weights of the horses were taken near the close of each month previous to the beginning of the experiment. Prior to the time covered by the experiment all the horses were fed practically alike and the two horses that comprise a team were usually worked together. The dotted line in Diagram I represents the average weights during this period of the three horses that were afterward fed oats during the experiment. The unbroken line is for the three horses that received corn during the experiment. That some variations may occur even when the same feeds are used is shown by Diagram I, page 251. Some fluctuations, then must be expected, and slight differences in weight cannot be attributed to the rations used, unless a uniform variation persists throughout a considerable number of weeks.

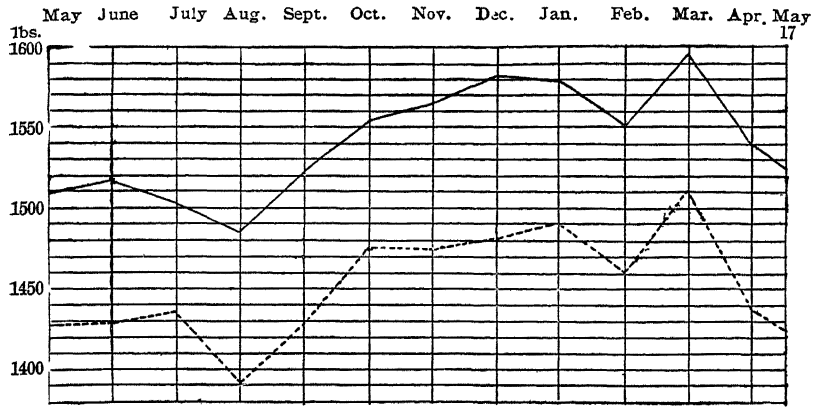


DIAGRAM I: Average monthly weights for year previous to experiment
Broken line for 3 horses later fed oats; unbroken line for 3 horses later fed corn.

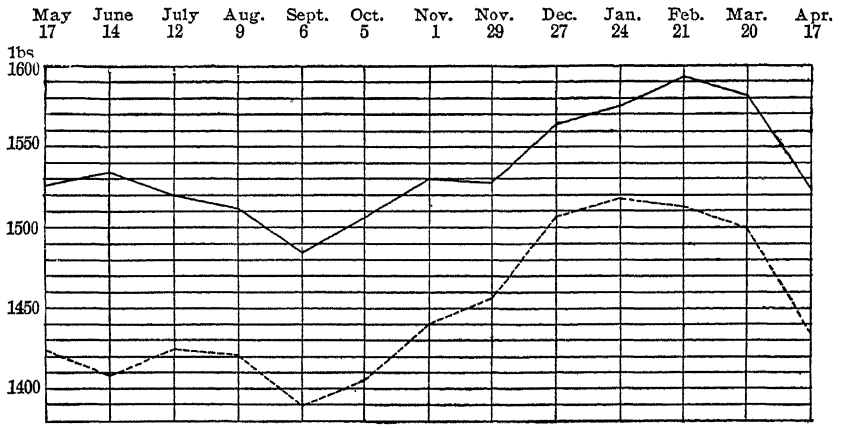


DIAGRAM II: Average weights for each four-week period of experiment.
Broken line for 3 oats-fed horses; unbroken line for 3 corn-fed horses.

Diagram II represents the variations in weights of the horses during the experiment. While the curves are scarcely as nearly parallel as they were prior to the experiment (see Diagram I) there is not any marked variation in opposite directions. Beginning November 1, shelled corn was fed to the corn-fed horses until January 24. During this period the weights of the corn-fed horses seemed to be rather lower than normal. This might possibly be due to the fact that the shelled corn was of hardly as good quality as the ear corn, or it may be that the shelled corn was not so thoroughly masticated and digested as the ear-corn, since the horses might eat it faster than the ear corn could be eaten. There is nothing in Diagram II to indicate that the use of corn during hot weather produced any undesirable effects. The variations that occurred in weight were so slight that no special significance can be attached to them.

SPIRIT AND ENDURANCE.

No difference due to the feeds used could be observed in the spirit and endurance of the horses. There are some differences in the various animals in respect to temperament, but this factor seems to be more largely dependent upon natural tendencies than upon the effect of any special kind of feed. It would, of course, be folly to say that a well-fed horse will not exhibit more spirit and endurance than will a horse that is fed such scant rations that it is improperly nourished. But this experiment has as yet yielded no evidence to indicate that the use of either corn or oats induces either sluggishness or activity.

AMOUNT AND COST OF FEED.

Table III shows the amount of feed consumed by each horse during each four-week period of the experiment, together with the number of hours' work done, total cost of feed and cost of feed per hour of work for each of these twelve periods. The cost of feed per hour of work in those periods during which little or no work was done is, of course much higher than the average. This suggests an important point in horse feeding: periods of partial or total idleness are expensive and should, so far as practicable, be eliminated. The total cost of feed and of feed per hour of work is based upon the following assumed values: Corn, 40 cents per bushel; oats, 30 cents per bushel; hay, $8 per ton. These prices did not prevail during the experiment but are more nearly average prices than were the ones which did prevail. Feeders may readily apply any market prices to the feeds under consideration, as the total amount of feed consumed by each horse is given.

TABLE III: Feed consumed and work performed during each four-week period.

Name of horse	Joe					Jake				
Period	Feed consumed		* Cost of feed	Hours work	* Cost of feed per hour of work	Feed consumed		* Cost of feed	Hours work	* Cost of feed per hour of work
	Hay	Corn				Hay	Oats			
	Lbs.	Lbs.				Lbs.	Lbs.			
May 17 to June 13..	504	485	$4.87	186	$.0262	504	486	$6.57	186	$.0353
June 14 to July 11..	459.5	472	4.61	201.5	.0229	459.5	472	6.26	201.5	.0311
July 12 to Aug. 8..	497	476	4.79	184	.0260	497	476	6.45	184	.0351
Aug. 9 to Sept. 5..	500	472	4.78	216.5	.0221	504	472	6.44	216.5	.0297
Sept. 6 to Oct. 3..	504	460	4.72	155	.0305	504	460	6.33	155	.0408
Oct. 4 to Oct. 31..	504	432	4.56	160.5	.0284	504	432	6.07	160.5	.0378
Nov. 1 to Nov. 28..	504	394	4.33	122.5	.0353	504	394	5.71	122.5	.0466
Nov. 29 to Dec. 26..	504	348	4.06	12.5	.3248	504	348	5.28	12.5	.4224
Dec. 27 to Jan. 23..	504	338	4.00	7.5	.5333	504	338	5.18	7.5	6907
Jan. 24 to Feb. 20..	502.25	336	3.99	0		499	336	5.15	0	
Feb. 21 to Mch. 19..	499	307	3.80	21	.1810	495.5	307	4.86	21	.2314
Mch. 20 to Apr. 16..	498.5	417	4.45	220	.0202	483.5	417	5.84	220	.0265
Totals	5980.25	4937	52.96+	1487	.0356	5962.5	4938	70.14+	1487	.0472
Name of Horse	Bill					Frank				
May 17 to June 13..	504	487	$4.88	212.5	$.0230	484	487	$6.50	212.5	$.0306
June 14 to July 11..	459.5	470	4.60	154 5	.0298	447.5	470	6.20	154.5	.0401
July 12 to Aug. 8..	497	469	4.75	132.5	.0358	493	474	6.42	132.5	.0485
Aug. 9 to Sept. 5..	501	464	4.73	145	.0326	464.5	464	6.21	145	.0428
Sept. 6 to Oct. 3..	504	458	4.71	161	.0293	477	458	6.20	161	.0385
Oct. 4 to Oct. 31..	504	414	4.45	104.5	.0426	502	414	5.89	104 5	.0564
Nov. 1 to Nov. 28..	504	408	4.42	141.5	.0312	489	408	5.78	141.5	.0408
Nov. 29 to Dec. 26 .	504	362	4.15	38.5	.1078	453	362	5.21	38.5	.1353
Dec. 27 to Jan. 23..	504	352	4.09	25	.1636	504	352	5.32	25	.2128
Jan. 24 to Feb. 20..	502.5	350	4.07	35	.1163	448	336	4.94	26.5	.1864
Feb. 21 to Mch. 19 .	504	333	3.97	64.5	.0616	425	317	4.67	62	.0753
Mch. 20 to Apr. 16..	518.5	417	4.53	216	.0210	460.5	379	5.40	216	.0250
Totals.....	6006.5	4984	53.35—	1430.5	.0373	5647.5	4921	68.74—	1419.5	.0484
Name of Horse	Tom					Dick				
May 17 to June 13..	323.5	478	$4.11	196	$.0210	504	478	$6.50	196	$.0332
June 14 to July 11..	376	470	4.27	197	.0217	459.5	470	6.24	197	.0317
July 12 to Aug. 8..	389	476	4.36	179	.0244	497	476	6.45	179	.0360
Aug. 9 to Sept. 5..	319.5	470	4.04	226	.0179	504	472	6.44	226	.0285
Sept. 6 to Oct. 3..	340	460	4.07	180.5	.0225	504	460	6.33	180.5	.0351
Oct. 4 to Oct. 31..	414	408	4.06	87.5	.0464	498	409	5.83	82.5	.0707
Nov. 1 to Nov. 28..	358	402	3.80	121.5	.0313	504	402	5.78	121.5	.0476
Nov. 29 to Dec. 26..	327	408	3.71	115.5	.0321	499	408	5.82	115 5	.0504
Dec. 27 to Jan. 23..	325	386	3.57	88.5	.0403	493	394	5.67	88.5	.0641
Jan. 24 to Feb. 20..	326	362	3.43	64	.0536	481	364	5.34	72.5	.0737
Feb. 21 to Mch. 19..	309.5	327	3.16	72	.0439	441	315	4.72	64	.0738
Mch. 20 to Apr. 16..	336.75	417	3.80	188	.0202	461	388	5.48	183	.0299
Totals.....	4144.25	5064	46.38—	1715.5	.0270	5845.5	5036	70.60—	1706	.0414

* Corn, 40c. per bushel; oats, 30c. per bushel; hay, $8.00 per ton.

The prices of feeds during the experiment were much higher than the prices assumed as the basis for Tables III and IV. Corn was worth not far from 60 cents per bushel on an average, while 50 cents was about the average price per bushel of oats. Under the market conditions that prevailed during the experiment the saving from the use of corn was very marked—approximately 10 cents per day for each horse for the entire 48 weeks. Market conditions should always be borne in mind, as there may be times during which oats would be cheaper than corn, and they should, of course, be used whenever cheaper.

Table IV presents a summary in which the three oats-fed horses are directly compared with the three corn-fed horses. It will be observed that the saving effected by the use of corn instead of oats was a material one, even upon the basis of the assumed prices. As was previously stated, Tom requires less feed than do the other horses; this fact should be borne in mind when the figures in Table IV are considered. The horses which received corn during the time covered by this bulletin are now being fed oats, while the ones which received oats are now being fed corn. It is believed that this matter of individuality will be overcome to a considerable extent by this reversing of rations. The reader is again cautioned to be sure to observe the assumed values upon which Tables III and IV are based, as different financial results would be secured if different valuations are applied.

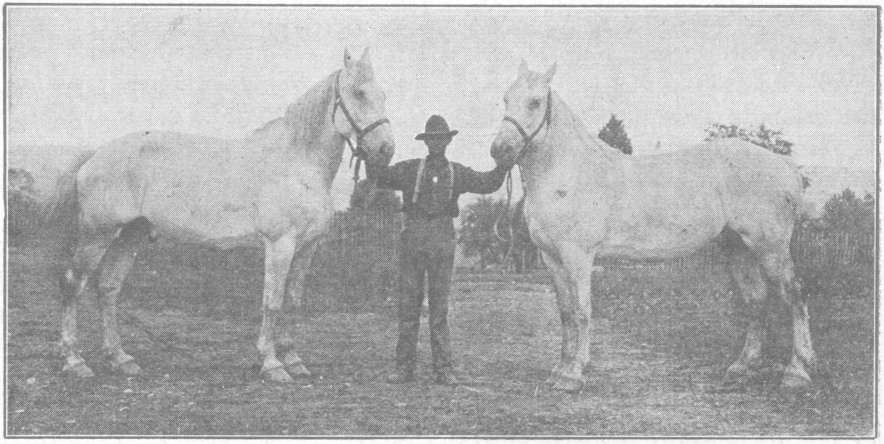
TABLE IV: Summary of feed and work.

	Initial weight May 16-17-18, '07	Final weight April 15-16-17, '08	Gain or loss in weight	Feed consumed			Total cost of feed consumed*	Hours work done	*Cost of feed per hour work
				Ear corn	Oats	Mixed Hay			
	lbs.	lbs	lbs.	lbs.	lbs.				cents
Joe.....	1,555	1,535	—20	4,937		5,980.25	$ 52.96	1,487	3.56
Jake.....	1,453	1,438	—15		4,938	5,962.50	70.14	1,487	4.72
Bill.....	1,493	1,486	— 7	4,984		6,006.50	53.34	1,430.5	3.73
Frank.....	1,470	1,473	3		4,921	5,647.50	68.72	1,419.5	4.84
Tom.....	1,527	1,545	18	5,064		4,144 25	46 37	1,715 5	2.70
Dick.....	1,349	1,389	40		5,036	5,845 50	70 59	1,706	4.14
Total corn-fed..	4,575	4,566	— 9	14,985		16,131.00	152.67	4,633	3 30
Total oats-fed..	4,272	4,300	28		14,895	17,455.50	209.46	4,612	4.54
Average corn-fed..	1,525	1,522	— 3	4,995		5,377 00	50.89	1,544.3	3.30
Average oats-fed..	1,424	1,433	9		4,965	5,818 50	69.82	1,537.5	4.54

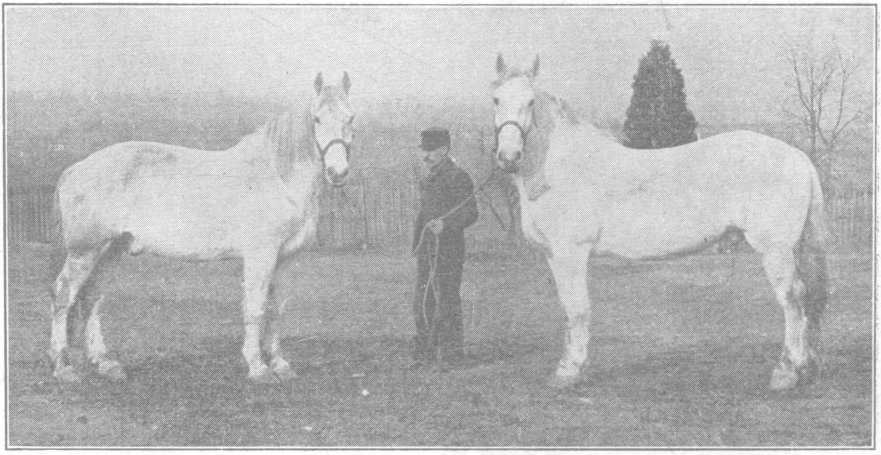
*Corn 40c. per bu.; oats, 30c. per bu.; hay, $8.00 per ton.

NUTRIENTS IN RATIONS CONSUMED.

As previously stated, samples of the oats, shelled corn and hay were analyzed. Table V, showing the total nutrients consumed by each horse, has been prepared on the basis of these analyses. It will be noted that the total dry matter, protein, and crude fiber consumed by the oats-fed horses of each team was in every instance greater than that consumed by its corn-fed team-mate. The nitrogen-free extract and the fat consumed by each of the two horses in a team was almost the same, save for Tom and Dick. Owing to the fact that Tom ate notably less hay than did Dick and the other horses. the total nutrients in Tom's ration are relatively low.



Jake; fed oats. August 5, 1907. Joe; fed corn.
After having received the separate grain rations for 101 days.



Jake; fed oats. January 3, 1908. Joe; fed corn.
After having received the separate grain rations for 252 days.

Jake; fed oats. May 11, 1908. Joe, fed corn.
After having received separate grain rations for 380 days.

The data presented in Table IV indicate that the nutrients in a given weight of ear-corn were approximately as efficient as the nutrients in an equal weight of oats. More than this, even with rations markedly lower in dry matter, protein and crude fiber, the corn-fed horses kept in equally as good condition as did the horses which received the oats ration. This would indicate that the efficiency of a given amount of total nutrients contained in corn is greater than that of the same amount of total nutrients in oats. It will be observed that the crude fiber is much lower in the corn than in the oats. A relatively large amount of energy is required to masticate and digest feeds that carry a large percent of crude fiber. Moreover crude fiber has a low digestibility as compared with that of the protein, fat or nitrogen-free extract.

TABLE V: Pounds of nutrients in feed consumed during 48 weeks.

	Feed	Dry matter	Protein	Crude fiber	Nitrogen-free extract	Fat
	Lbs.					
Joe	*4,073.025 corn	3,597.581	392.232	74.536	2,900.808	173.389
	5,980.25 hay	5,190.977	374.364	2,066.356	2,321.533	123.672
	Total	8,788.558	766 596	2,140 892	5,222.341	297.061
Jake	4,938 oats	4,432.596	617.250	538 291	2,934.357	174.311
	59,625 hay	5,175 569	373.253	2,060.223	2,314 643	123.305
	Total	9,608 165	990.503	2,598 514	5,249.000	297.616
Bill	*4,111.8 corn	3,631.830	395.966	75.246	2,928.424	175.039
	6,006.5 hay	5,213.762	376.007	2,075.426	2,331.723	124 215
	Total	8,845.592	771.973	2,150 672	5,260.147	299 253
Frank	4,921 oats	4,417.336	615.125	536.438	2,924.255	173.711
	5,647.5 hay	4,902.143	353.534	1,951.381	2,192.360	116.790
	Total	9 319.479	968.659	2 487.819	5 116.615	290 501
Tom	4,177.998 corn	3,690.300	402.341	76.457	2,975.570	177.857
	4,144.25 hay	3,597.292	259.430	1,431.963	1,608.798	85.703
	Total	7,287.592	661 771	1,508.420	4 584.368	263 560
Dick	5,036 oats	4,520.565	629.500	548.974	2,992.593	177.771
	5,845.5 hay	5,074.011	365.928	2,019.796	2,269.223	120.885
	Total	9 594.576	995.428	2 568.770	5,261.816	298.656

*Ear-corn was fed most of the time; calculated to shelled corn on the basis of 82.5% shelled corn, as yielded by sample shelled in August, 1907. Figures given above are for shelled corn.

If it is taken into consideration that work horses are kept to perform labor, that is, to apply energy, the reason for corn being so efficient is not difficult to understand. The composition of corn

(see Tables I and VI) shows it to be comparatively low in crude fiber, which requires a large amount of energy to handle; and comparatively high in nitrogen-free extract, which is efficient in producing energy.

The protein requirement of mature work horses seems to be considerably lower than has been thought by some investigators. Whether or not the corn and mixed hay ration used in this experiment supplied an excess of protein is not certain. However, one fact is evident—the corn ration was, for the period covered by the experiment, practically as efficient as the oats ration, and contained less protein. It must be understood that this experiment was conducted with mature geldings. The protein requirement of brood mares that are either pregnant or suckling foals, or both, would be expected to be much higher than that of the horses used in this test. The results of this test cannot be considered directly applicable to work horses that are immature, as they would require protein for growth. However, it seems entirely probable that the rational use of corn for young horses, supplementing it if necessary with nitrogenous milling by-products, would in many cases materially lessen the cost of maintenance and growth. It must also be borne in mind that the hay used in this experiment contained a considerable amount of clover. For use with pure timothy hay, corn might prove less efficient than oats. It might be said here that, as a rule, pure timothy hay is not more efficient as a horse feed than is well cured mixed hay, which, wherever clover may be successfully grown, has the advantage of yielding heavier crops than timothy.

Dr. C. F. Langworthy presented in Bulletin 125, Office of Experiment Stations, U. S. Dept. of Agriculture, a table showing a comparison of various feeds on the basis of percentage composition, digestible materials in 100 pounds of the feed, and energy in the digestible materials contained in 100 pounds feed. The energy values of the different feeds are expressed in calories, a calory being "the amount of heat which would raise the temperature of 1 kilogram of water 1 degree C. or 1 pound of water 4 degrees F."

TABLE VI: Composition, digestibility and energy value of corn and oats.*

	Percentage composition						Digestible materials in 100 Lbs.				Energy in digestible nutrients in 100 pounds feed
	Water	Protein	Fat	Nitrogen-free extract	Crude fiber	Ash	Protein	Fat	Nitrogen-free extract	Crude fiber	
	%	%	%	%	%	%	Lbs.	Lbs	Lbs.	Lbs.	Cal.
Corn, dent.	10.6	10.3	5 0	70.4	2 2	1 5	5 95	2 39	62 09	....	136,636
Oats.....	11 0	11.8	5.0	59.7	9.5	3.0	9.39	3.60	45 25	2 82	122,062

*From Table 1, Bulletin 125, Office of Experiment Stations, U. S. Department of Agriculture.

Table VI is quoted from the table referred to, and shows a comparison of corn and oats on the basis of percentage composition, digestible nutrients contained in 100 pounds of the feed, and energy in the digestible nutrients in 100 pounds of the feeds.

The digestible nutrients in 100 pounds of oats, according to these figures, contain as much energy as the digestible nutrients in 89.3 pounds of shelled corn. In the experiment under discussion, the equivalent of 82.5 pounds of shelled corn was compared with 100 pounds of oats. The results of this experiment indicate that there is a wide difference between the food value of a pound of oats and that of a pound of shelled corn. The value of the two feeds for maintaining work horses compared rather closely with the calculated energy value as presented above, although corn showed a higher value than the figures in Table VI would indicate.

It is altogether probable that more energy is required in masticating and digesting the oats than the corn, as there is more crude fiber in the oats. Whatever the disposition of the two feeds in the animal body, the fact remains that for practical feeding of work horses under the conditions of this experiment, 100 pounds of oats proved approximately equal to 100 pounds of ear-corn, which yielded 82.5 pounds of shelled corn.

A FRENCH OPINION.

E. Lavalard, a French authority, considers corn a valuable feed for horses at hard work. His opinion, based upon long experience and wide observation, is well given in the following:

Indian Corn—Our first experiments in this line [substitution of other feeds for oats] were made with Indian corn. They were undertaken with all kinds of horses and gave most satisfactory results. The *Compagnie générale des voitures* and the *Compagnie générale des omnibus* began about 1870 to feed Indian corn, and the results were so satisfactory that since that time the first-named company has almost entirely ceased to feed oats. The latter company has continued to feed both oats and corn, effecting a saving of from 1,000,000 to 1,500,000 francs per year. In view of these facts the opponents of corn have been forced to admit that it is a suitable feed for draft horses. They have insisted, however, that since it does not contain the so called stimulating principle 'avenine' it should not be used for saddle horses and others where speed is required. Examples of the successful use of corn were cited in the author's earlier publications. The horses of the French expedition in Mexico were fed exclusively on corn. Our recent experiments on cavalry and artillery horses have shown that Indian corn may generally replace oats without in any way causing the horses to deteriorate. The horses fed the corn ration were used the same number of hours in the military drill and in the maneuvers, and were ridden at the same gait as those fed exclusively on oats, and it was practically impossible to perceive the least difference between the two classes. The army officers, prejudiced as they naturally were, were forced to admit that all the horses showed the same energy and vigor. A careful record showed that the sickness and mortality were the same with horses on the two rations.

"Corn and oats are quite similar in composition. In experiments made at the laboratory of the *Compagnie générale des omnibus* in co-operation with Muntz, the author found very high co-efficients of digestibility for corn, as shown by the following results: Protein 86.1, fat 93.9, sugar and starch 100, crude fiber 82 8, saccharifiable fiber 86.9, undetermined substances 85.2 per cent. These co-efficients show that the nutritive ingredients of corn are much more assimilable than has been generally believed in Europe. As regards physical character, oats contain on an average 70 to 75 percent of kernel and 25 to 30 percent of indigestible hull, which resembles straw in composition. The skin or hull of maize amounts to practically nothing.. These facts show why horses thrive better and are more apt to maintain their weight on corn than on oats. Our recent experiments have demonstrated that corn can replace oats in the ration of both cavalry and artillery horses, and if substituted weight for weight it increases the nutritive value of the ration. This is the same deduction which was drawn from the experiments, now [1900] more than 25 years old, made for the two great cab companies of Paris." *

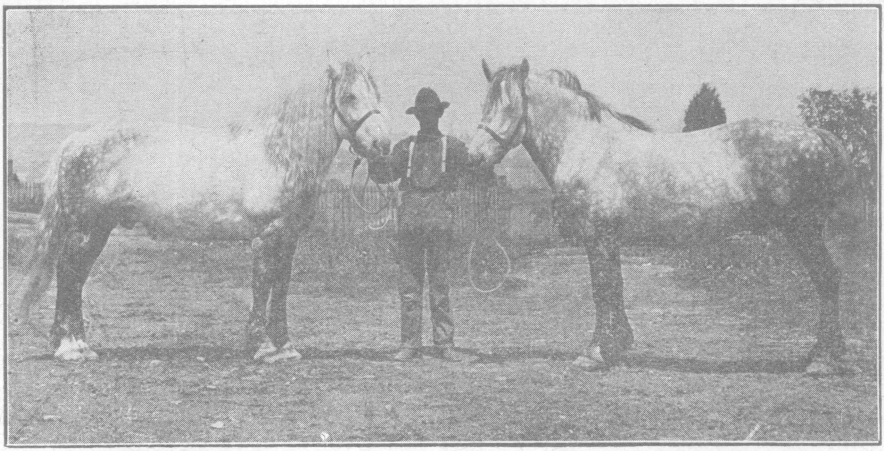
From the foregoing it is evident that the writer's experience is favorable to the use of corn for horses at hard work, from the standpoint of both efficiency and economy.

PRICES OF CORN AND OATS DURING 42 YEARS.

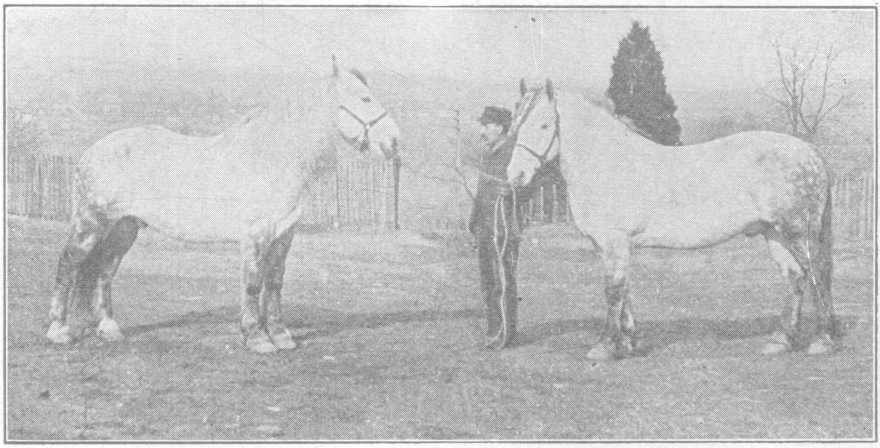
The economic importance of an understanding of the comparative values of corn and oats for horse feeding is, perhaps, better brought out by the figures in Table VII than by any statements that have been made in the previous discussion. The figures that represent farm prices of corn and oats for the various years in this table are from the 1906 Yearbook, U. S. Department of Agriculture and the Bureau of Statistics. The feeding value of oats for each of the years from 1866 to 1907 inclusive is based upon the results of this experiment and the home value of corn as given in the table.

It is of interest to note that, under the conditions of this experiment, there was not a year in the 42 years covered by the table in which oats had a feeding value as high as their farm value. A comparison of the columns entitled "Farm value of oats per bushel Dec. 1," and "Feeding value of oats" will show the relation which these values bore to each other for each of the 42 years. In no year was the feeding value of oats, based upon the prevailing price for corn and the results of this experiment, as high as the farm value. In other words, every bushel of oats fed when corn could have been used with as good results and substituted for oats at the price given for corn occasioned an actual loss to the feeder. On the basis mentioned the greatest loss per bushel of oats fed occurred in 1907, when the feeding value of oats was 20 cents per bushel less than the market value.

*Extract from an article published in the Experiment Station Record Vol. XII, p. 4.



Dick; fed oats. August 5, 1907. Tom; fed corn.
After having received the separate grain rations for 101 days.



Dick; fed oats. January 3, 1908. Tom; fed corn.
After having received the separate grain rations for 252 days.

Dick; fed oats. May 11, 1608. Tom, fed corn.
After having received the separate grain rations for 380 days.

The above does not mean that oats are never worth more for feed than the figures given in the table would indicate, since there may be cases in which corn cannot be substituted for oats without undesirable results being obtained. However, when this substitution might have been made with no ill effects,—and the results of this experiment indicate one set of conditions under which it may—a very material saving would have been effected.

TABLE VII: Comparison of market value and feeding value of oats.

Year	Average farm price of corn per bushel Dec. 1†	Average farm price of oats per bushel Dec. 1†	Feeding value* of oats per bushel	Year	Average farm price of corn per bushel Dec. 1	Average farm price of oats per bushel Dec. 1†	Feeding value of oats per bushel*
	Cents	Cents	Cents		Cents	Cents	Cents
1866	47.4	35.1	22.3	1887	44 4	30.4	20.9
1867	57.0	44.5	26.8	1888	34.1	27.8	16 0
1868	46.8	41.7	22.0	1889	28.3	22.9	13.3
1869	59 8	38.0	28.1	1890	50.6	42.4	23.8
1870	49 4	39 0	23.2	1891	40.6	31.5	19.1
1871	43 4	36 2	20.4	1892	39 4	31.7	18.5
1872	35.3	29 9	16.6	1893	36.5	29.4	17.2
1873	44.2	34.6	20.8	1894	45 7	32.4	21.5
1874	58 4	47.1	27.5	1895	25 3	19.9	11.9
1875	36.7	32.0	17.3	1896	21.5	18.7	10.1
1876	34.0	32 4	16.0	1897	26.3	21.2	12.4
1877	34.8	28.4	16.4	1898	28.7	25 5	13.5
1878	31.7	24 6	14.9	1899	30.3	24.9	14.3
1879	37.5	33.1	17.6	1900	35 7	25.8	16.8
1880	39.6	36.0	18 6	1901	60 5	39.9	28.5
1881	63.6	46.4	29.9	1902	40 3	30.7	19.0
1882	48.5	37.5	22.8	1903	42 5	34.1	20.0
1883	42.4	32.7	20.0	1904	44.1	31 3	20.8
1884	35.7	27.7	16.8	1905	41.2	29.1	19.4
1885	32.8	28 5	15 4	1906	39 9	31.7	18.8
1886	36 6	29 8	17.2	1907	51.6	44.3	24.3

*On basis of farm value of corn for same year, and results of the experiment reported in this bulletin, with mature geldings fed mixed clover and timothy hay.

†1906 Yearbook, U. S. Dept. of Agr. and data from Bureau of Statistics.

SUMMARY.

While the work reported in this bulletin has not been conducted for a sufficient length of time nor with enough animals to justify any very comprehensive statements, yet it seems that some facts have been pretty well established. The work is being continued, and it is hoped that the cumulative effects, if any result, of the long continued use of grain rations made up exclusively of corn and of oats may be determined. The following statements, based upon the work done thus far, seem to be warranted by the data presented heretofore. It must be understood that *the horses were mature geldings* and that *mixed clover and timothy hay was fed.*

The corn-fed horses endured hard work during hot weather as well as did the oats-fed horses.

The use of corn to the exclusion of other grain for a period of 48 weeks was not detrimental to the health of work horses.

The use of corn for work horses did not induce laziness and lack of endurance. Neither did the use of oats induce increased spirit and endurance. (Page 252.)

When mixed (clover and timothy) hay was fed to mature geldings at general farm work, ear-corn was practically as efficient, pound for pound, as oats. (Page 254.)

On the basis of the results of this experiment and statistical records of farm values of grains, corn has, since 1866, been cheaper than oats as a grain feed for work horses. (Page 261.)

The drop in weight of the corn-fed horses, coincident with the beginning of the use of shelled corn, indicates that ear-corn is to be preferred above shelled corn for work horses. (Page 251.)

Farm animals should be fed according to their needs. Their needs depend, of course, upon the product that they yield. Work horses are kept for applying energy and should be supplied with feeds that will furnish the required energy at the least possible cost, all things considered.

There is a wide difference in the efficiency of horses in utilizing feed. This is well illustrated by the record of the horse Tom used in this experiment. There is an "individuality" in work horses as well as in other farm animals. Horses that are notably hard to keep in good condition should be replaced by ones that may be maintained at less cost. (Page 254).

The data presented do not prove that, for use with pure timothy hay, ear-corn is as efficient, pound for pound, as oats. Neither is any evidence at hand to indicate that a grain ration made up exclusively of corn is suitable for brood mares with foal or in milk, or for young, growing horses.

When the weights of the horses for the year previous to the experiment are compared with the weights secured during the experiment, it is seen that the exclusive use of either corn or oats has not had any bad effect upon the horses. There is no positive proof, however, that a mixed ration would not be more efficient than one made up exclusively of corn or of oats. This experiment does show, nevertheless, that corn is a valuable feed for work horses and should be given a large place in their rations, whenever market conditions warrant its use. (Pages 251, 254).

It is obvious that feeds for work horses should be palatable, efficient and economical. As far as palatableness is concerned, corn seems, in the experience of this Station, to have a slight advantage over oats, although this will depend to a considerable extent upon the individual appetite. The results obtained thus far in the experiment reported in this bulletin indicate that corn is an

efficient feed for work horses. The bulk of an amount of ear-corn equal in feeding value to the usual amount of oats is small—so small that a casual observation might lead one to believe that too little corn was being used. As regards economy, ear-corn is usually cheaper per pound than oats, while this experiment indicates that ear-corn and oats are worth approximately the same per pound for feeding under the conditions stated previously.

Further work along this line with additional horses is now under way, and will be reported later.